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Central and Arctic Region
Canadian Science Advisory Secretariat
Science Advisory Report 2014/002

ASSESSMENT OF STRESSORS, IMPACTS AND PATHWAYS OF EFFECTS FOR THE DARNLEY BAY ANUNIAQVIA NIQIQYUAM AREA OF INTEREST FOR MARINE PROTECTED AREA DESIGNATION

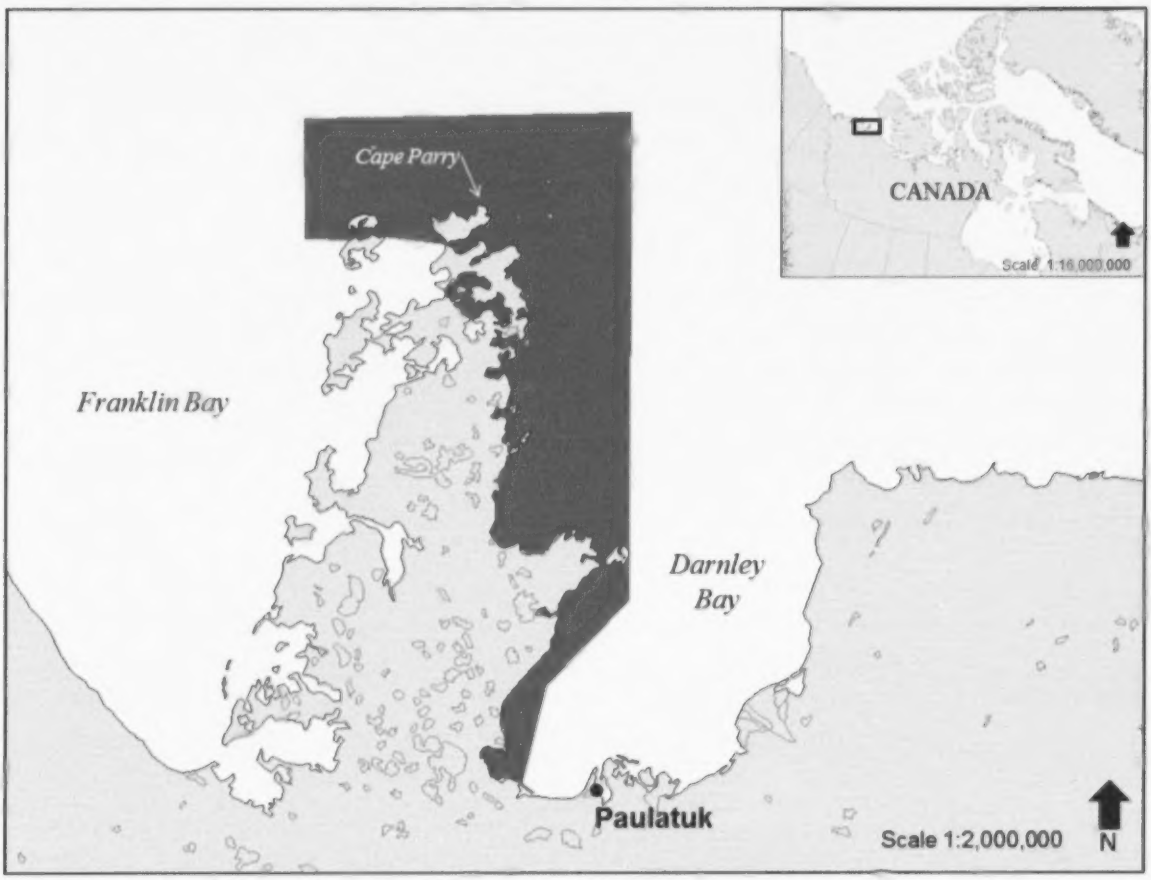

Figure 1. The Anuniaqvia Niqiqyuam Area of Interest (ANAOI), Northwest Territories, is identified by the dark shaded area.

Context:

Canada's Oceans Act *(1997) authorizes Fisheries and Oceans Canada (DFO) to provide enhanced protection to areas of the oceans and coasts which are ecologically or biologically significant by designating marine protected areas (MPAs). Under the Health of the Oceans Initiative, DFO Science provides advice in support of the identification and development of MPAs following the selection of an area of interest (AOI). Science advice is used to identify and prioritize ecosystem issues and to inform the development of management strategies, action plans, research prioritization and the drafting of the regulatory impact analysis statement (RIAS).*

May 2014

Canada

In late 2010, DFO Science identified areas within Darnley Bay which met the criteria for marine protection under the Oceans Act, provided advice on boundaries for those areas and identified conservation objectives (DFO 2011). Based on this advice, the AOI Steering Committee in Paulatuk, Northwest Territories, included a portion of the Cape Parry Offshore Marine Feeding Habitat within the Anuniaqvia Niqiqyuam Area of Interest (ANAOI). The Steering Committee also referred to traditional and local knowledge to add the west side of Darnley Bay to the ANAOI.

As a precursor to the RIAS, DFO Oceans Programs requested that DFO Science evaluate a pathways of effects model approach to identify the activities and associated stressors that have the potential to affect valued ecosystem components in the ANAOI.

SUMMARY

- Valued ecosystem components (VECs) for the Anuniaqvia Niqiqyuam Area of Interest (ANAOI) include Beluga Whale, Arctic Char, Ringed Seal, Bearded Seal, and their habitats, identified through traditional ecological knowledge, and ecosystem integrity and trophic links identified through scientific knowledge. VECs were considered to include the species' habitat (including prey).
- Activities or drivers associated with the immediate area (i.e., specific drivers) with the potential to impact the VECs in the ANAOI include commercial fishing, dredging, infrastructure development, mining, port construction and operation, recreational fishing, scientific research activities, seismic surveys, shipping, subsistence hunting and fishing, and tourism.
- Pathways of effects (PoE) models were developed for each of the eleven specific drivers and resulting stressors to illustrate the cause/effect relationship. The risk (likelihood and impact) of each pathway was not assessed.
- In addition to the 11 specific drivers noted above, four drivers (pervasive drivers) were identified which include climate variability and change, contaminant transport, Arctic Ocean acidification and invasive/colonizing/vagrant species. These may also impact the ANAOI although specific PoE models were not developed for these.
- Main stressor categories included effects of artificial lighting, ballast water inputs, biota removal, contaminants, gear loss, habitat alteration and destruction, invasive species introductions, noise, sampling, ship strikes, and species' disturbance. Where possible mechanisms and effects were identified.
- The PoE models developed provide simplistic representations of the potential relationship between the activity, stressors and effects on VECs in the ANAOI. They do not illustrate synergistic or cumulative effects.

BACKGROUND

In late 2010, Fisheries and Oceans Canada (DFO) Science sector identified an area of interest (AOI) in Darnley Bay which met the criteria for marine protection under the Oceans Act. Science provided advice on boundaries for key areas and identified conservation objectives (DFO 2011). The Anuniaqvia Niqiqyuam AOI (ANAOI) Steering Committee decided on the final areas and boundaries and included a portion of the Cape Parry Offshore Marine Feeding Habitat in the ANAOI (Figure 1).

The conservation objective that was developed by DFO Science for this area is:

> *"to maintain the integrity of the marine environment offshore of the Cape Parry Migratory Bird Sanctuary (MBS) so that it is productive and allows for high trophic level feeding by*

ensuring that the Cape Parry polynyas and associated sea-ice habitat, and the role of key prey species (e.g., Arctic Cod), are not disrupted by human activities"

The Steering Committee also included a portion of the west side of Darnley Bay in the ANAOI (Figure 1). The conservation objectives for this area were developed by the community of Paulatuk and Steering Committee members, based on traditional and local knowledge (TK) (Kavik-AXYS Inc. 2012). The TK conservation objective developed for this area is:

"to maintain the habitat to support populations of key species (beluga, char, ringed and bearded seals)"

Six VECS were identified for the ANAOI. The science review (DFO 2011) identified Ecosystem Integrity and Trophic Links (EI/TL). Traditional or local knowledge identified Beluga (B), Arctic Char (C), Ringed Seal (RS), Bearded Seal (BS), and their Habitat (H), including their prey.

ASSESSMENT

This assessment follows the approach DFO (2012) developed to assess the potential risk that human activities may have on ecosystem components to refine MPA management. Although based on a risk assessment, the framework begins with identification of key features or properties of the system (i.e., VECs, species, habitats and community/ecosystem properties), human activities or drivers, and the resulting stressors with the potential to affect VECs using PoE models. Once this is done, the risk of harm to each VEC from each driver and associated stressors is assessed using appropriate criteria and scoring methods. This latter step was not part of the current assessment although there was an informal risk assessment inherent in the process when identifying potential drivers and stressors.

Oil and gas development and related activities were not evaluated as DFO Oceans Program indicated that there is no known potential for these activities in the ANAOI.

Drivers and stressors were not limited to those occurring directly in the ANAOI as activities outside the area may affect the VECs directly or the habitat and ecosystem quality that brings VECs to the ANAOI. For example, activities that impact the Arctic Char populations in the Brock and Hornaday rivers would affect use of the ANAOI by this VEC.

Activities/Drivers

Four pervasive drivers that likely have or will have impacts on the ANAOI were identified. They are: climate variability and change; contaminant transport; Arctic Ocean acidification; and invasive/colonizing/vagrant species. These may influence the ecosystem, for example by amplifying effects. Pervasive drivers may need to be considered in a risk assessment. PoE models were not developed for these drivers.

This assessment focused on 11 drivers that have the potential to affect VECs in the ANAOI. The importance of each driver was not evaluated. They included commercial fishing, dredging, infrastructure development, mining, port construction and operation, recreational fishing, scientific research, seismic surveys, shipping, subsistence hunting and fishing, and tourism.

Commercial fishing

Commercial fishing in the Darnley Bay region or further in the Beaufort Sea has the potential to impact VECs in the ANAOI (Figure 2). The impacts of this activity are broadly based on vessel impacts, gear impacts, and mortality of targeted and bycatch species. Impacts would be primarily local although could be widespread depending on the target, extent and location of a commercial fishery. Presently, no commercial fisheries occur in the ANAOI.

Dredging

Dredging has the potential to impact VECs in the ANAOI (Figure 3). Dredging may be used for shipping channels, or around port facilities. In addition, dredging could be used as a source for gravel for land-based infrastructure development. The impacts of this activity are broadly based on vessel impacts (noise, contaminants and invasive species) or the changes to seafloor and water column resulting from removing and/or depositing dredged material. Dredging equipment can transport species between areas when the equipment is moved with species entrained. The impacts tend to be primarily localized although noise from dredging would be transitory.

Infrastructure development

Infrastructure development has the potential to impact VECs in the ANAOI (Figure 4). This category refers to a suite of activities that include water withdrawal, road construction, gravel mining on land, increased human presence, increased airstrip use and/or new construction. It links to several of the other drivers, particularly dredging.

Mining

Mining development has the potential to impact VECs in the ANAOI (Figure 5). Mining increases the occurrence of other drivers, such as shipping, infrastructure development, and port construction/operation. Mining occurs on land but has potential downstream effects that are considered here. Water withdrawals and de-watering may be associated with mining activities but were discussed as potential stressors under Infrastructure development. Although airborne contamination is possible, leakage from tailings ponds or spills were considered in the PoE model. Crushed rock and spoiling that are deposited in the nearshore environment are considered here. These effects are generally localized to the site of the deposits. Effects can be felt downstream if tailing ponds and containment berms fail.

Port construction and operation

Port construction and operation has the potential to impact VECs in the ANAOI (Figure 6). It is linked to dredging and shipping activities. Some effects would occur only locally at the port site during the construction phase. For example, injury or mortality of VECs could occur due to the use of explosives during port construction. Artificial lighting could impact birds and polar bears over the long-term. There is the potential for low level but constant noise during construction phase and periods when the port is in use that could impact species behaviour. Atmospheric emissions resulting from both port construction and operation have the potential to cause changes to sea ice as a result of particulates (soot, black carbon) that settle on sea ice.

Recreational fishing

Recreational fishing has the potential to impact VECs in the ANAOI (Figure 7). Recreational fishing tends to be small-scale and targets freshwater fishes and/or sea run fishes while in freshwater resulting in mortality or biota removal. The activity may also involve camping. Overall effects are likely minimal.

Scientific research

Scientific research has the potential to impact VECs in the ANAOI (Figure 8). The range of stressors relates to the various types of research activities (ship-based, land-based camp) the focus of the research, the types of gear, etc. Research may be conducted from large research ships or icebreakers or smaller local vessels, depending on the objectives. Most of the impacts of this activity in the PoE model are based on vessel and gear impacts.

Seismic surveys

Seismic surveys have the potential to impact VECs in the ANAOI (Figure 9). PoE models for seismic surveys have been developed and are available (Coker et. al., 2010). Although impacts from vessels (including artificial light) are linked to this activity, the principal stressor is noise.

Shipping

Shipping has the potential to impact VECs in the ANAOI (Figure 10). Shipping refers to tugs, barges, icebreakers and other ships/vessels which carry cargo. Shipping is not generally a winter activity although it is possible for icebreaking to occur throughout the winter particularly in the future as climate change causes ocean temperatures to warm. Changes in sea-ice as a result of icebreaking activities are considered here. The activity may directly affect VECs particularly marine mammals (ship strikes, noise impacts). The ship operations may input chemicals (antifoulants, hydrocarbon spills) into the environment. Ships may also introduce invasive species (ballast water, hull fouling). Effects occur along the shipping route. Ballast water, if exchanged or dumped, may alter the environment.

Tour boats and private yachts are considered under Tourism. Propeller wash, typically localized to the dock site, is considered under Port Construction and Operation.

Subsistence hunting and fishing

Subsistence hunting and fishing has the potential to impact VECs in the ANAOI (Figure 11). Targeted species will experience mortality while other impacts are associated with vessel operation and the establishment of temporary camps. Impacts would be primarily local although could be widespread depending on the target and location of the activity.

Tourism

Activities related to tourism have the potential to impact VECs in the ANAOI (Figure 12). Tourism activities considered included cruise ships and their landing craft (e.g., zodiacs) as well as pleasure yachts. Regulations, guidelines, or ethics associated with tourism activities may already or could play a role in mitigation of impacts. The effects identified are localized to the site of anchorage and/or beaching. Effects while moving would be considered under Shipping.

Ice cover was not considered as Canadian Coast Guard icebreakers do not escort cruise ships in this region.

Tourism may differ from shipping if there are ethics or regulations associated with reducing noise while approaching wildlife although tourism could still cause species disturbance.

Small vessels under 100 tonnes Gross Registered Tonnage (most yachts and pleasure vessels) do not fall under Arctic Waters Pollution Prevention Regulations, so are permitted to release sewage while underway. The effects from sewage would be localized and likely minimal.

Stressors and Effects

Pathways of effects models were developed for each driver/stressor combination. For each driver there are associated stressors and resulting effects (and sub-effects) that have the potential to impact the ecosystem. In Figures 2 to 12 the stressors are illustrated using bold font in darker-coloured boxes below the driver. Various combinations of the following stressors resulted from the eleven drivers:

- Artificial Lighting
- Ballast Water
- Biota Removal

- Contaminants
- Gear Loss
- Habitat Alteration and Destruction
- Invasive Species
- Noise
- Sampling
- Ship Strikes
- Species Disturbance

Effects are illustrated in Figures 2 to 12 using lighter-coloured boxes. In some cases additional sub-effects are provided in colourless boxes. VECs that are impacted are shown below each relevant pathway. The proceedings report (DFO 2014) provides details of the Pathways of Effects models illustrated in Figures 2 to 12.

Sources of uncertainty

Numerous drivers/stressors have been identified that could impact VECs in the ANAOI although the direct impact that these might have is currently uncertain. There is a need for more causative studies to evaluate the impact of each threat. Threat likelihood and impact at the VEC level are currently unknown.

How the pervasive drivers identified for the ANAOI may impact the drivers/stressors evaluated is also unknown. A risk assessment of the threats was not undertaken.

CONCLUSIONS AND ADVICE

Valued ecosystem components (VECs) for the Anuniaqvia Niqiqyuam Area of Interest (ANAOI) include Beluga, Arctic Char, Ringed Seal, Bearded Seal, and their habitats (including prey), as identified by traditional ecological knowledge and ecosystem integrity and trophic links as identified by scientific knowledge.

Human activities (drivers) with the potential to impact these VECs include commercial fishing, dredging, infrastructure development, mining, port construction and operation, recreational fishing, scientific research activities, seismic surveys, shipping, subsistence hunting and fishing, and tourism. Drivers were not limited to those within the ANAOI as activities outside the area may affect the VECs directly or indirectly through changes to their habitat.

Pathways of effects (PoE) models were developed for each of these eleven drivers. Each model included the driver and stressor (i.e., direct result of the human activity) to illustrate the cause/effect relationship. Stressor categories included effects of artificial lighting, ballast water inputs, biota removal, contaminants, gear loss, habitat alteration and destruction, invasive species introductions, noise, sampling, ship strikes, and species' disturbance. More detailed effects of the drivers and stressors were identified where possible. There was no risk assessment (likelihood and impact) undertaken to evaluate the importance of any of the pathways described. Each model provides a simplistic representation of the potential relationship between the driver, stressor and effect(s) on VECs in the ANAOI. They do not illustrate synergistic or cumulative effects.

In addition to these eleven drivers, four pervasive drivers were identified including climate variability and change, contaminant transport, Arctic Ocean acidification and invasive/colonizing/vagrant species. Although these may also impact the ANAOI, PoE models were not developed.

SOURCES OF INFORMATION

This Science Advisory Report is from the February 6-7, 2013 Darnley Bay Area of Interest for Marine Protected Area designation: assessment of stressors, impacts and Pathways of Effects. Additional publications from this meeting will be posted on the DFO Science Advisory Schedule as they become available.

Coker, G.A., Ming, D.L., and Mandrak, N.E. 2010. Mitigation guide for the protection of fishes and fish habitat to accompany the species at risk recovery potential assessments conducted by Fisheries and Oceans Canada (DFO) in Central and Arctic Region. Version 1.0. Can. Manuscr. Rep. Fish. Aquat. Sci. 2904: vi + 40 p.

DFO. 2011. Identification of Conservation Objectives and Boundary Delineation for the Darnley Bay Area of Interest (AOI). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/009.

DFO. 2012. Risk-based Assessment Framework to Identify Priorities for Ecosystem-based Oceans Management in the Pacific Region. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/044.

DFO. 2014. Proceedings of the regional assessment of stressors, impacts and pathways of effects for the Darnley Bay Area of Interest for Marine Protected Area designation. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2014/001.

Kavik-AXYS Inc. 2012. Traditional and Local Knowledge Workshop for the Paulatuk Area of Interest. Report prepared for DFO, Inuvik, NT. 46 p.

APPENDIX 1. PATHWAYS OF EFFECTS MODELS

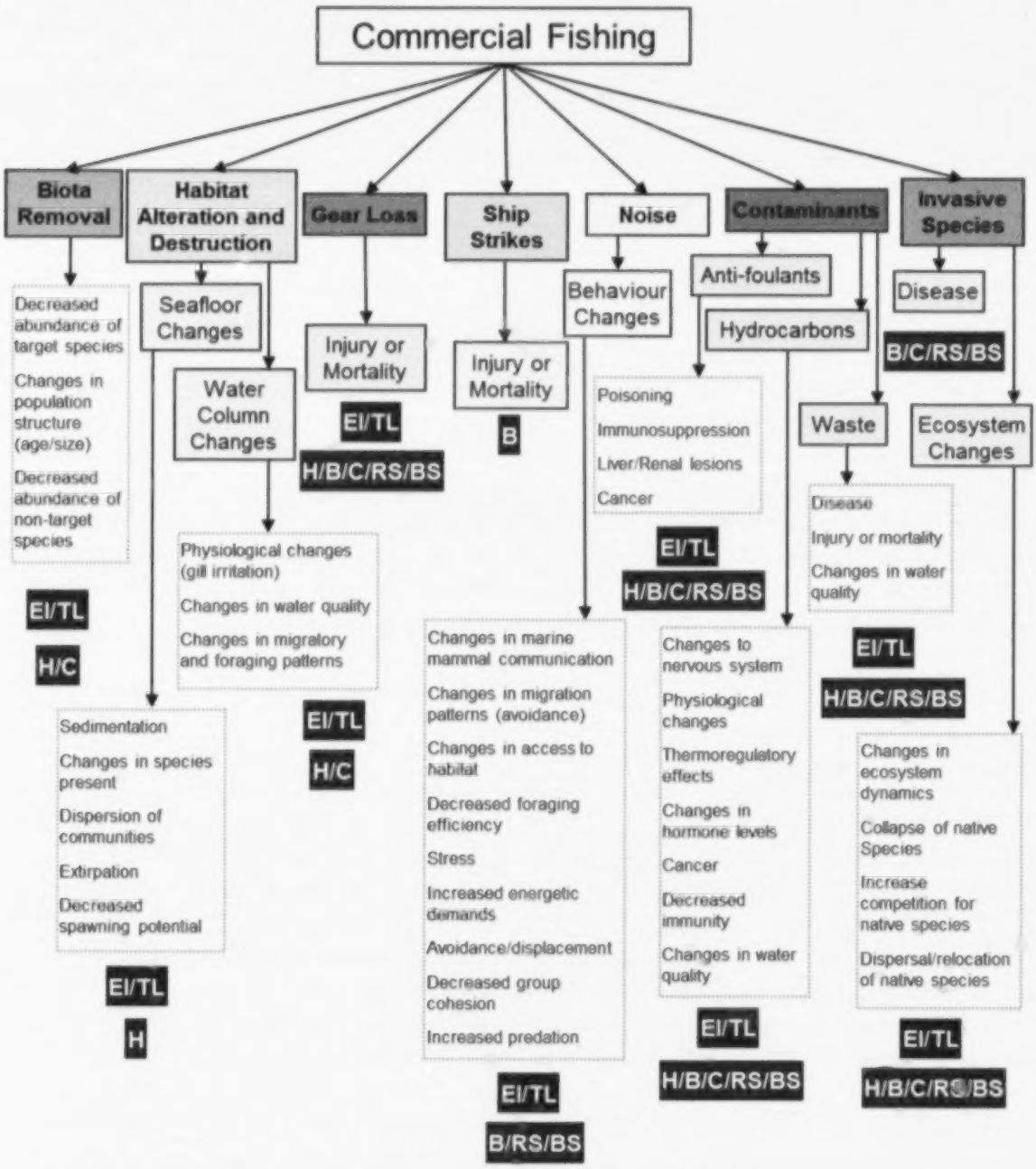

Figure 2. Pathways of Effects model for commercial fishing impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

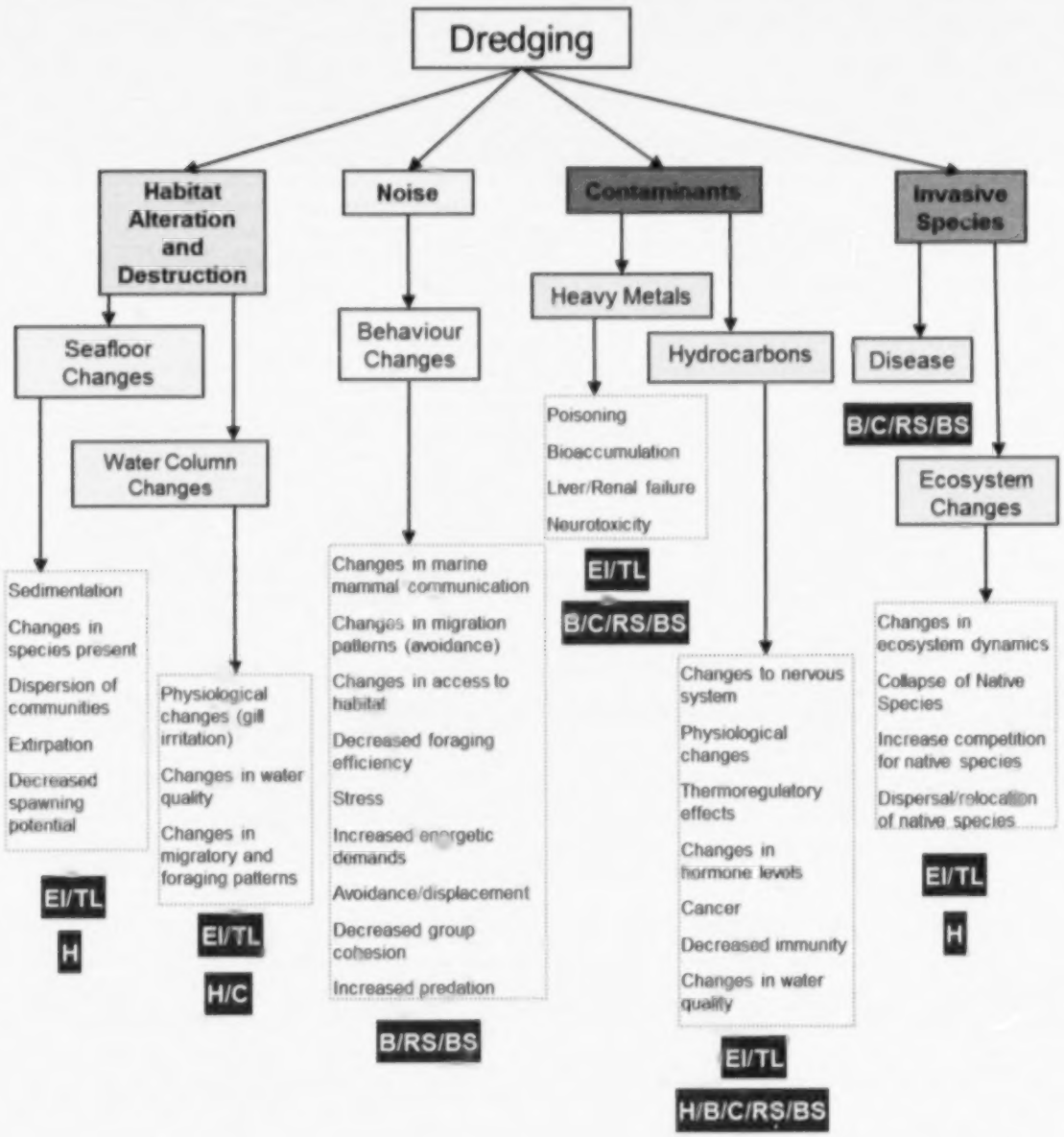

Figure 3. Pathways of Effects model for dredging impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

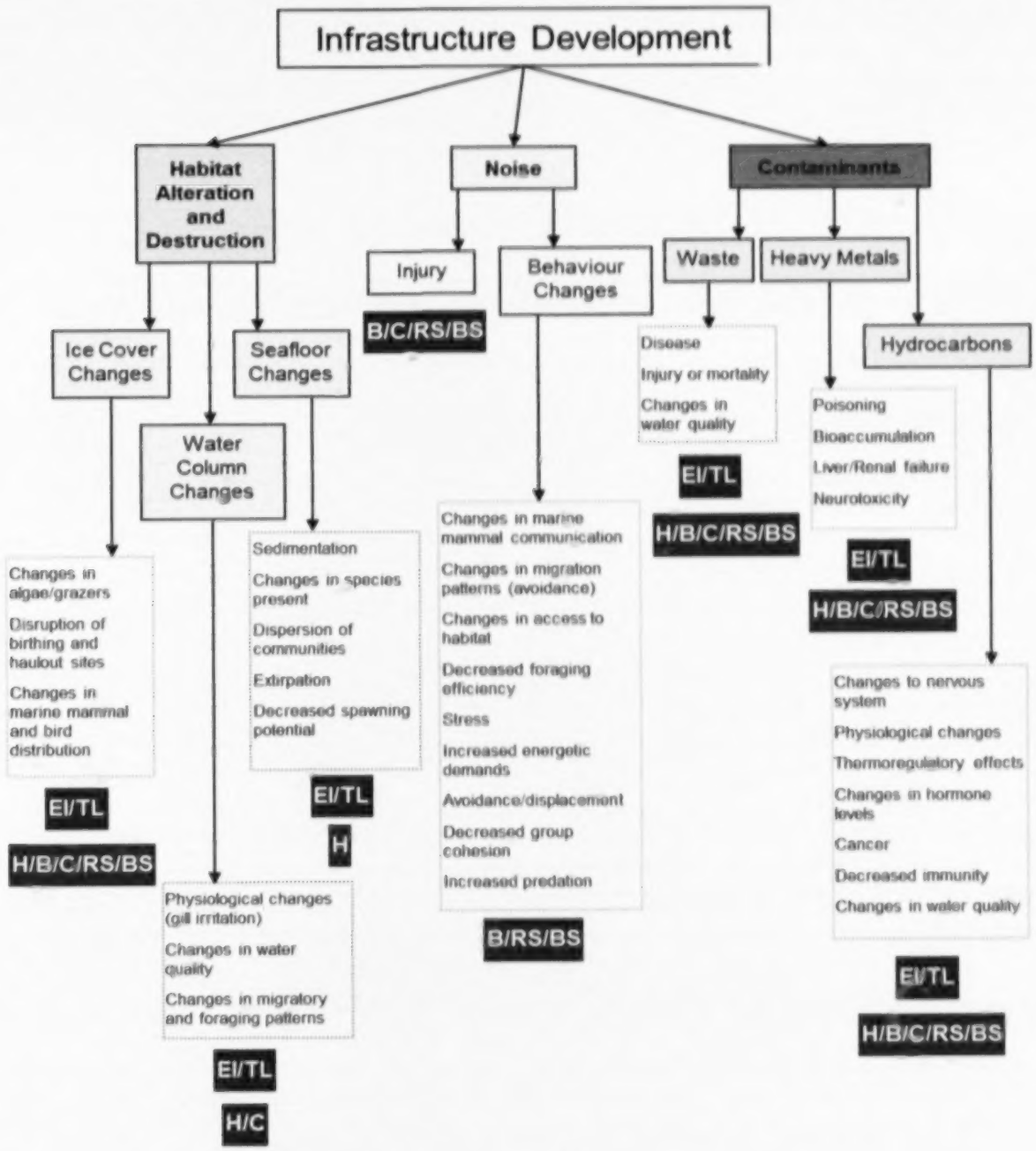

Figure 4. Pathways of Effects model for infrastructure development impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

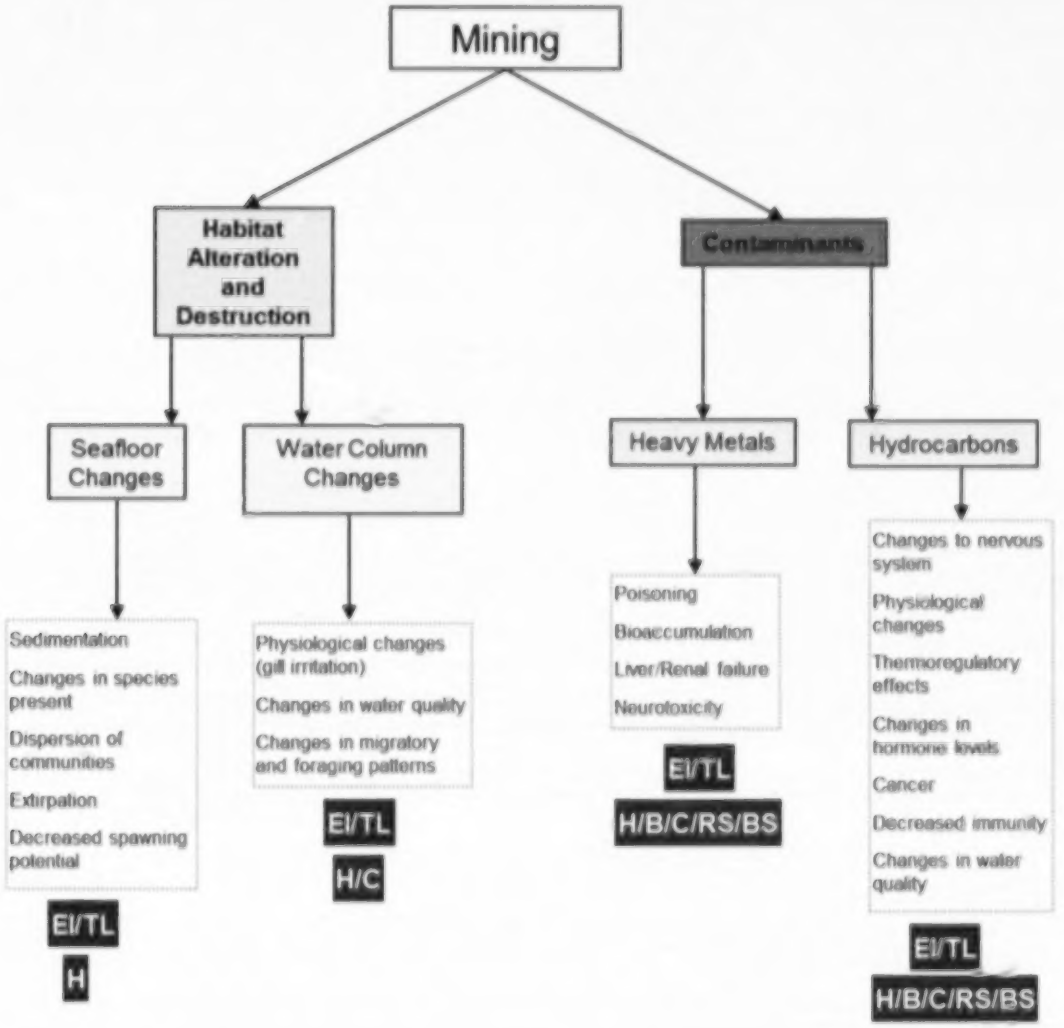

Figure 5. Pathways of Effects model for mining impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

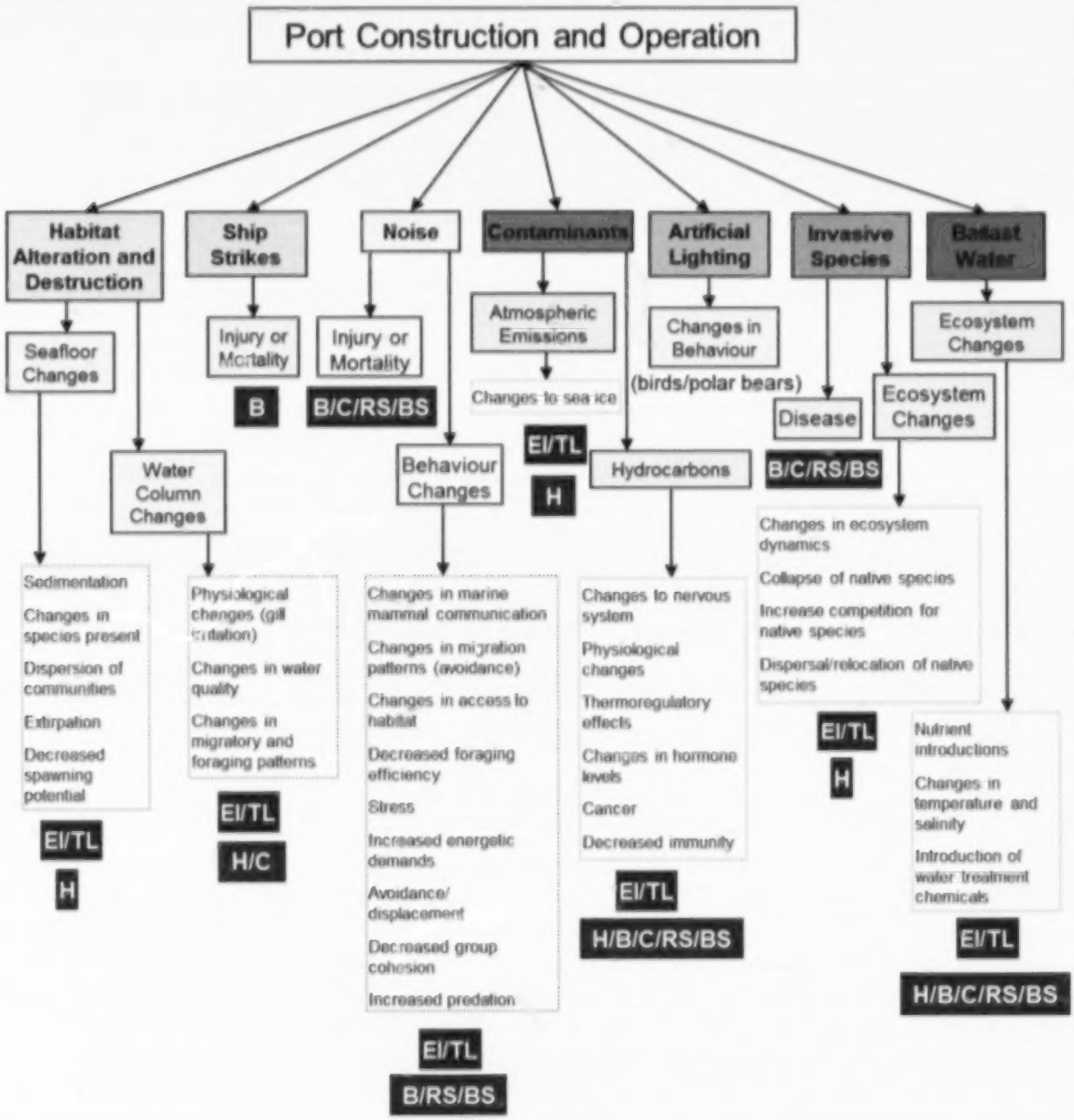

Figure 6. Pathways of Effects model for port construction and operation impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

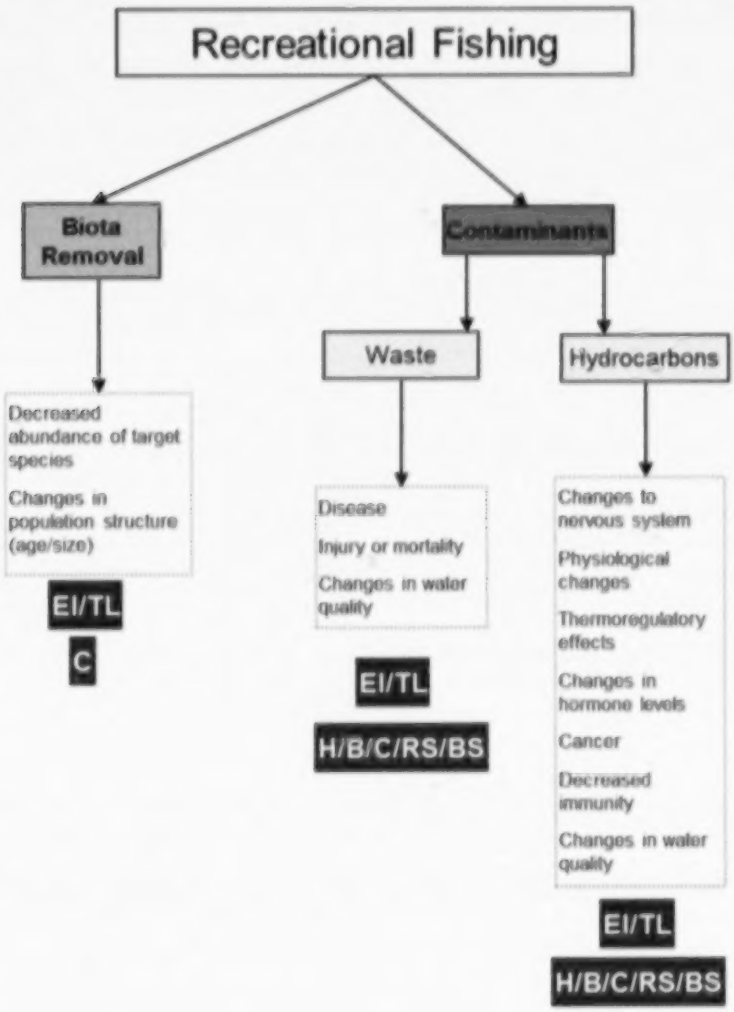

Figure 7. Pathways of Effects model for recreational fishing impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

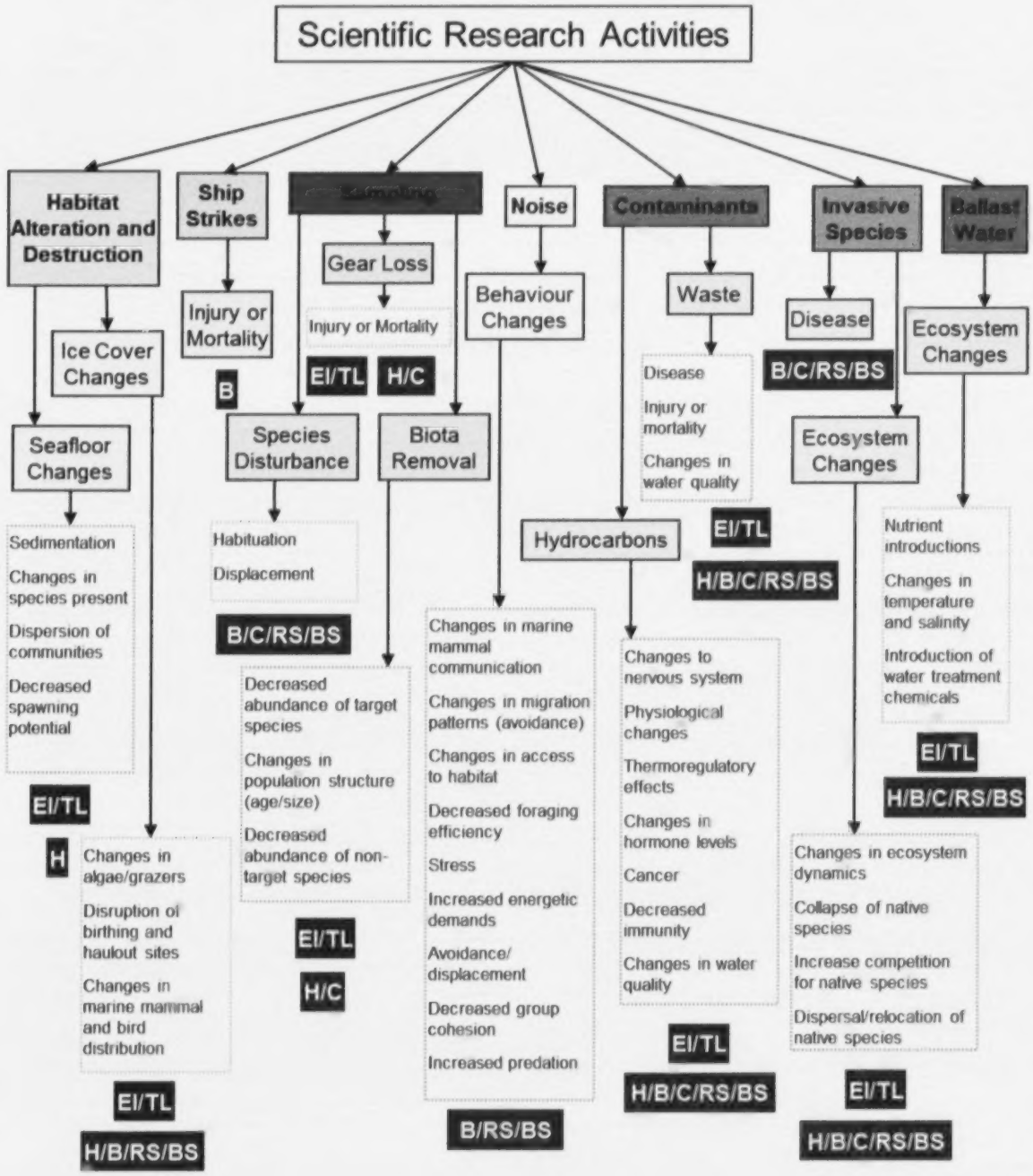

Figure 8. Pathways of Effects model for scientific research impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

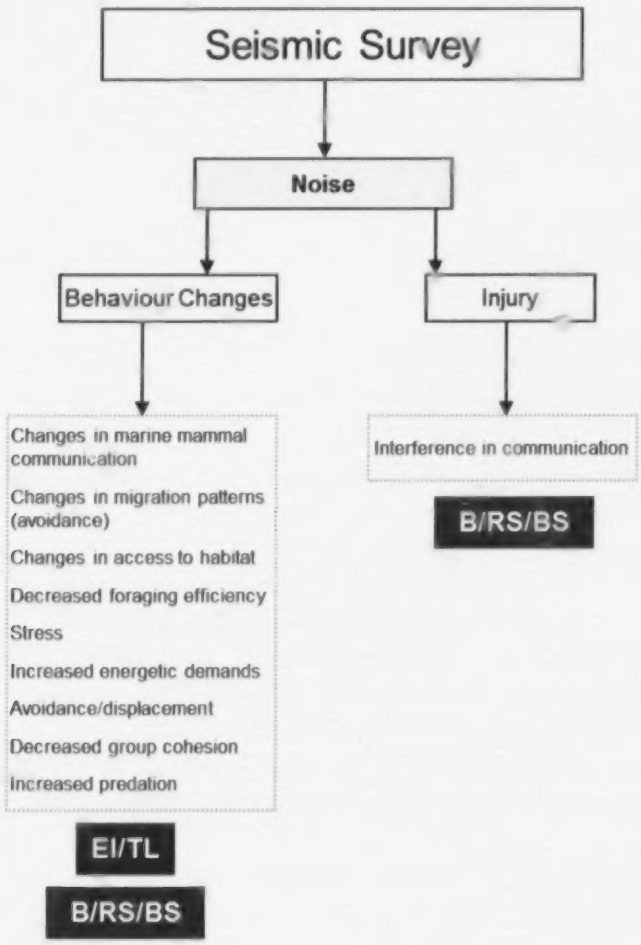

Figure 9. Pathways of Effects model for seismic survey impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

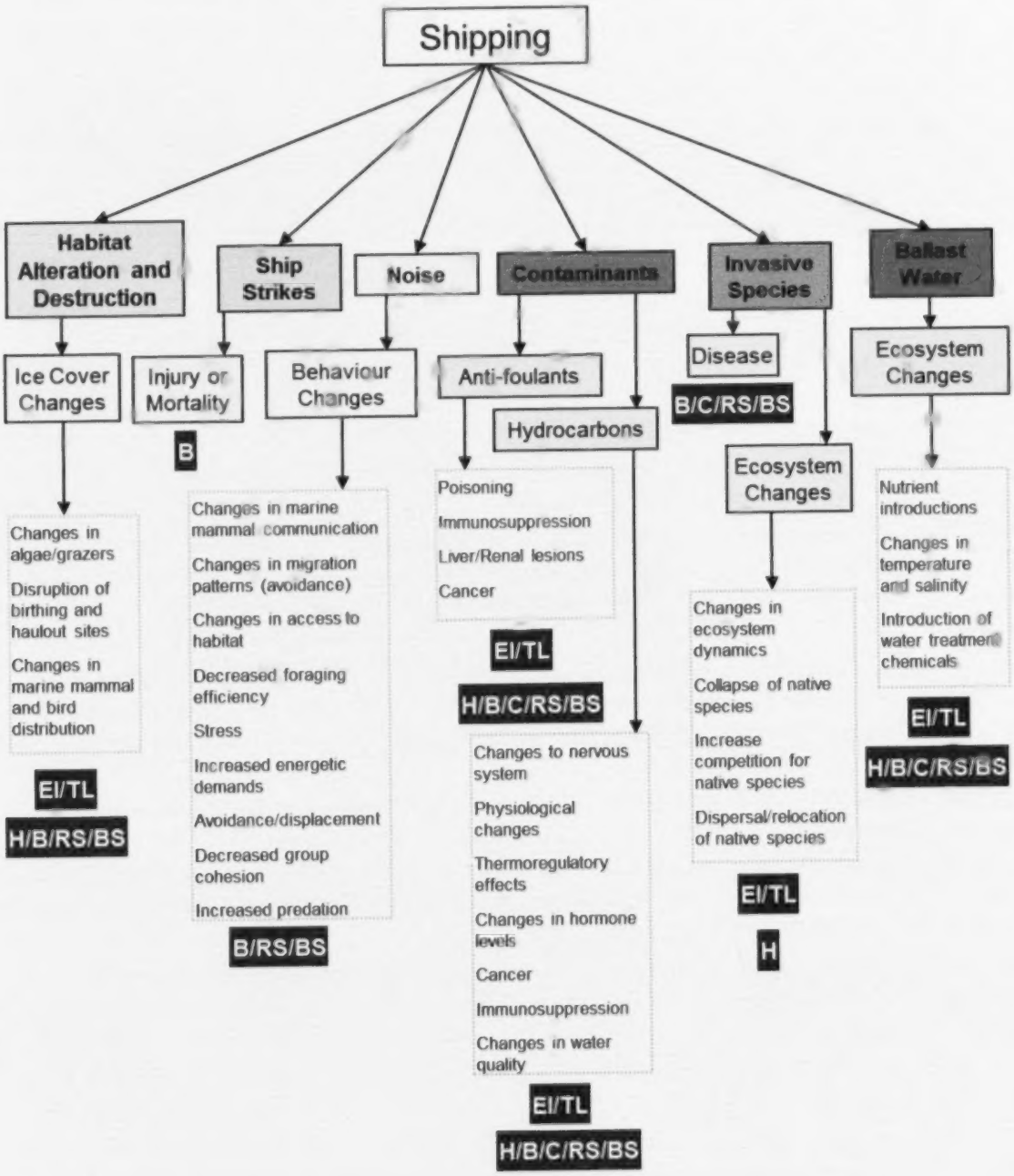

Figure 10. Pathways of Effects model for shipping impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

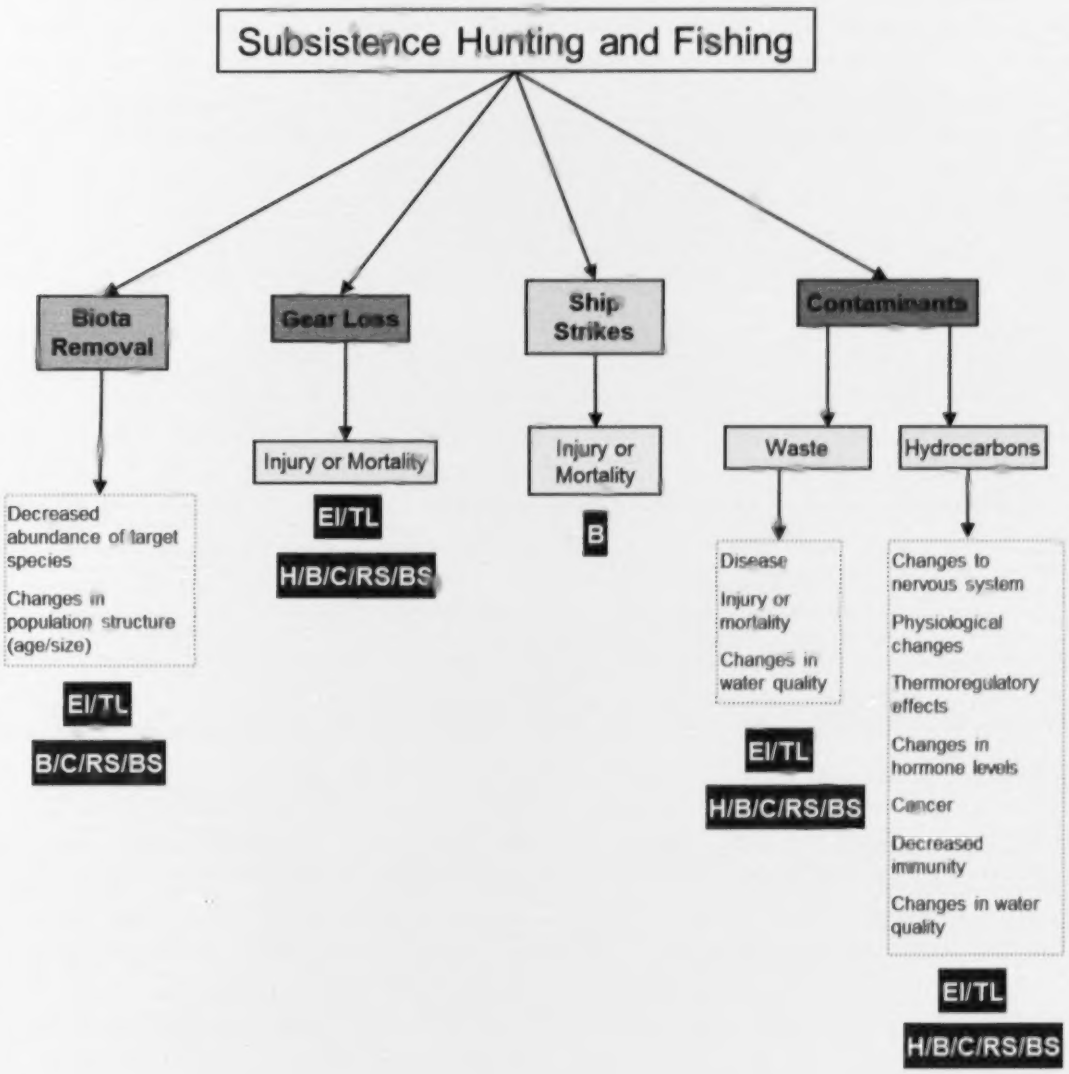

Figure 11. Pathways of Effects model for subsistence hunting and fishing impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

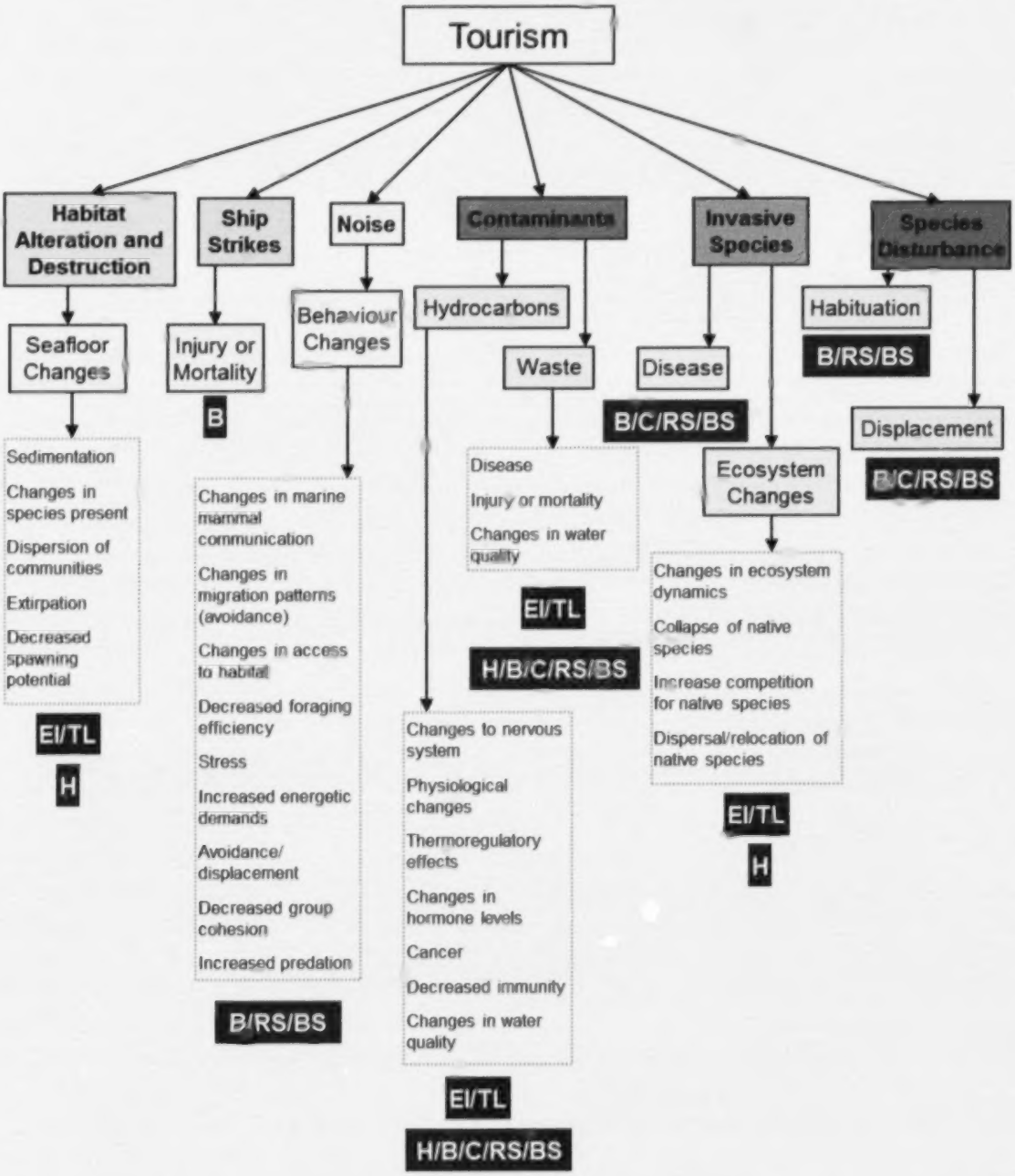

Figure 12. Pathways of Effects model for tourism-related impacts on Valued Ecosystem Components (VECs) in the ANAOI. Stressors (bold font, darker-coloured boxes), their effects (linked, lighter-coloured boxes) and sub-effects (colourless boxes) are shown to impact the science VEC (Ecosystem Integrity and Trophic Link [EI/TL]) and/or traditional knowledge VECs (Habitat [H], Beluga [B], Arctic Char [C], Ringed Seal [RS] and Bearded Seal [BS]).

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